

# **CONSTRUCTION OF HIGH CAPACITY DAM ANCHORS**

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# *A Brief Overview*

- Introduction
- Access Related Issues
- Drilling, Redrilling & Recesses
- Water Testing & Consolidation  
Grouting
- Upper Anchorage Installation
- Installation & Grouting

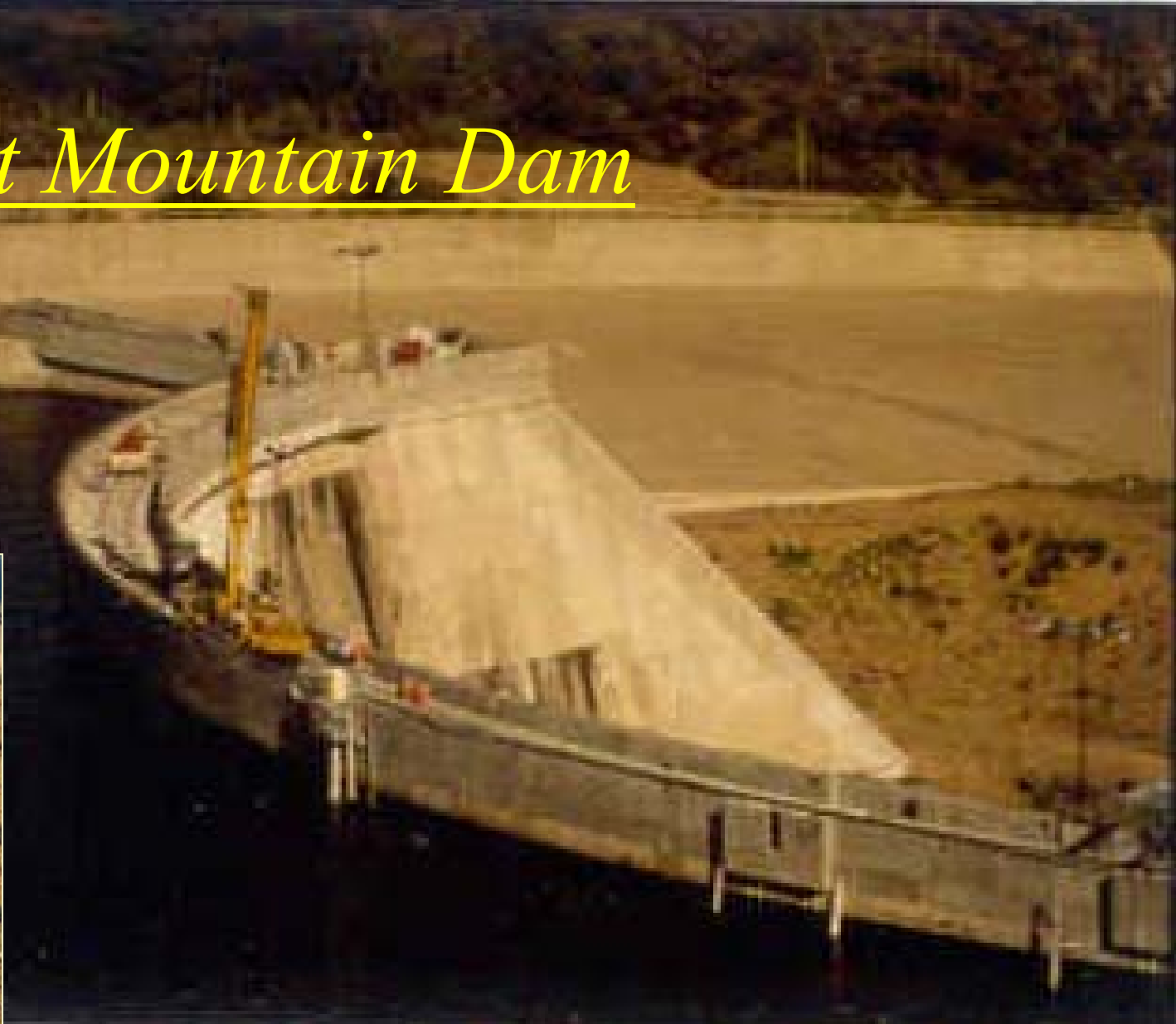
# *Introduction*

- For purposes of this presentation, high capacity anchors are 12-strands or more, up to 61-strands.
- Largest application of high capacity tendons is for dam anchoring.
- Class I corrosion protected anchors requiring corrugated diameters from 4"ID to 10"ID.
- Corresponding drill hole diameters from 7" to 15".

# *Access*

- Access and environmental issues are the first construction challenges.
- All projects have different requirements:
  - Access from top of dam, land or barge
  - Drill may be large, small, from leads or reconfigured
  - Work may be staged from surface, barge or platform
- Cuttings and fluids are diverted or pumped away from waterways.
- Debris have been blown 45-ft vertical and up to 1500-ft horizontal.

# *Stewart Mountain Dam*



# Lake Lynn





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# *Great Falls Dam*



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# Shepaug





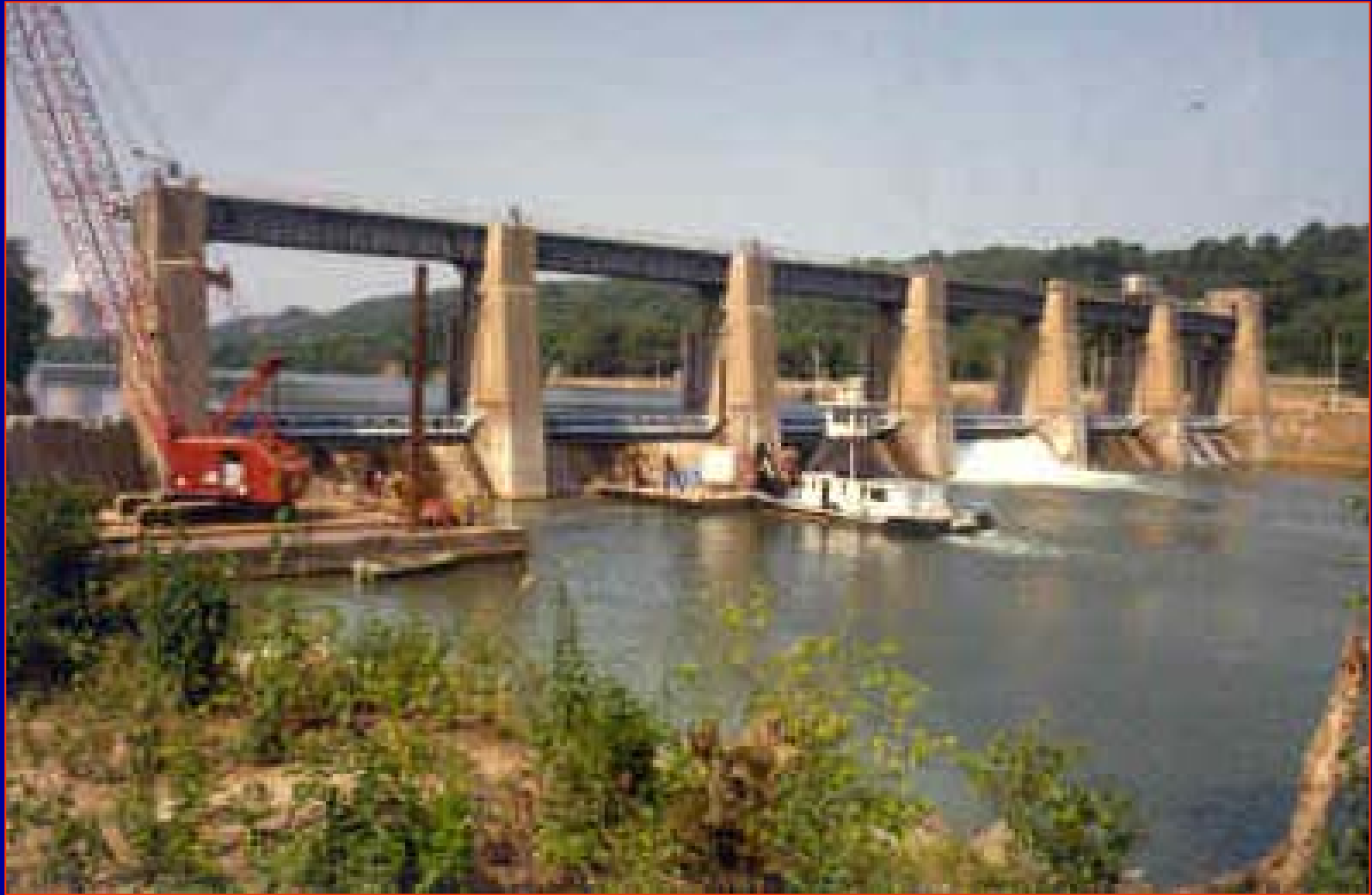
# Boonton Dam







# *Point Marion*







*Hauser Dam*





# Wesley Seale



# *Drilling -Equipment*

- Most commonly used drills are small track mounted rigs such as Davey Kent DK525, or equal.
- Drills are compact and lightweight with a high retraction force for pulling heavy tooling.
- Most drilling is done with down-hole-hammer tools using high pressure air.
- Typical compressor is a 900-cfm x 350-psi.
- Required air volume is function of rod size and hole diameter.





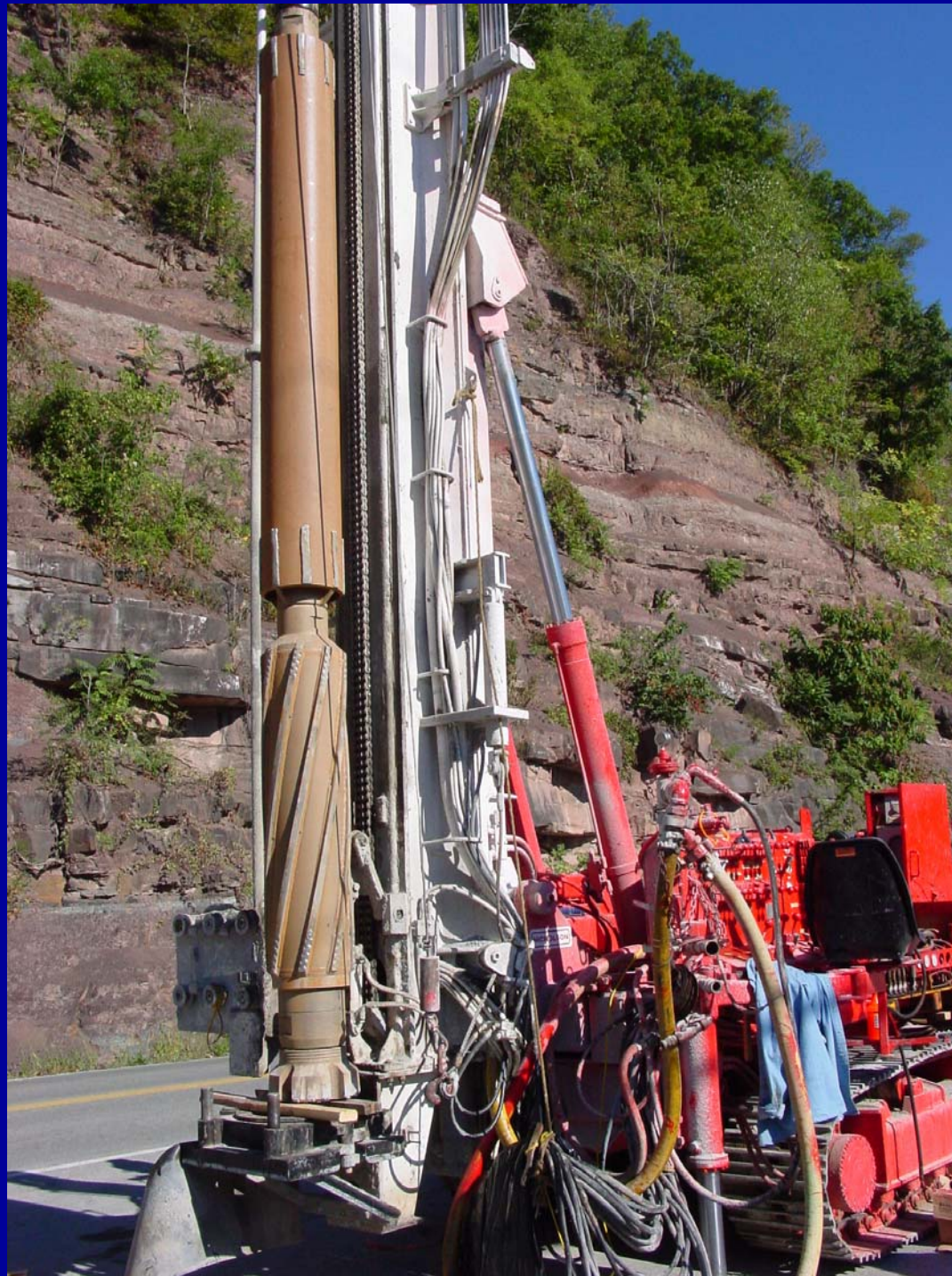


# *Drilling - Deviation*

- Specifications should be dependent on physical conditions and/or geometry of dam.
- Usually not more than 1-degree. Often specified as 1" in 10-ft (0.48-degrees). Sometimes specified as 1" in 15-ft (0.32-degrees).
- Specification should take into consideration accuracy of instrument.
- Magnetic based instruments are most economical (R-Singleshot & EMS).
- Gyroscopic instrument (Seeker) is most accurate.

# *Drilling - Hole Stabilization*

- Initial setup and drill tool stabilization is key to proper hole alignment.
- Hole stabilizers are sized 1/4" less diameter of drill hole.
- Total length of stabilizers should be 15-ft to 25-ft. Usually made up of ribbed over-hammer stabilizer followed by "can" or "flow-thru" type stabilizers.
- Down pressure on drill should be kept minimal when using down-hole-hammer. Not much more than weight of drill string.



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# *Drilling - Initial Setup*

- Accuracy of initial drill string alignment is critical to drilling within tolerance.
- For standard tolerances, hole is checked several times over the first 10-feet with “Smart-Level” to within 0.1-degree.
- For tighter tolerances, the trumpet assembly, sized as a drill guide sleeve is surveyed and grouted into a pilot hole.
- Recess is drilled prior to drill hole in this set up.



# *Drilling - Recess*

- Recesses are usually drilled with an eccentric hammer tool.
- Tool consists of a down-hole-hammer fabricated to a guide pipe.
- Recesses are cut round, sized up to 40” diameter.
- Larger recess will require line drilling or saw cut and jack hammer excavation.
- Diameter of recess is often governed by the jack chair rather than the bearing plate dimensions.



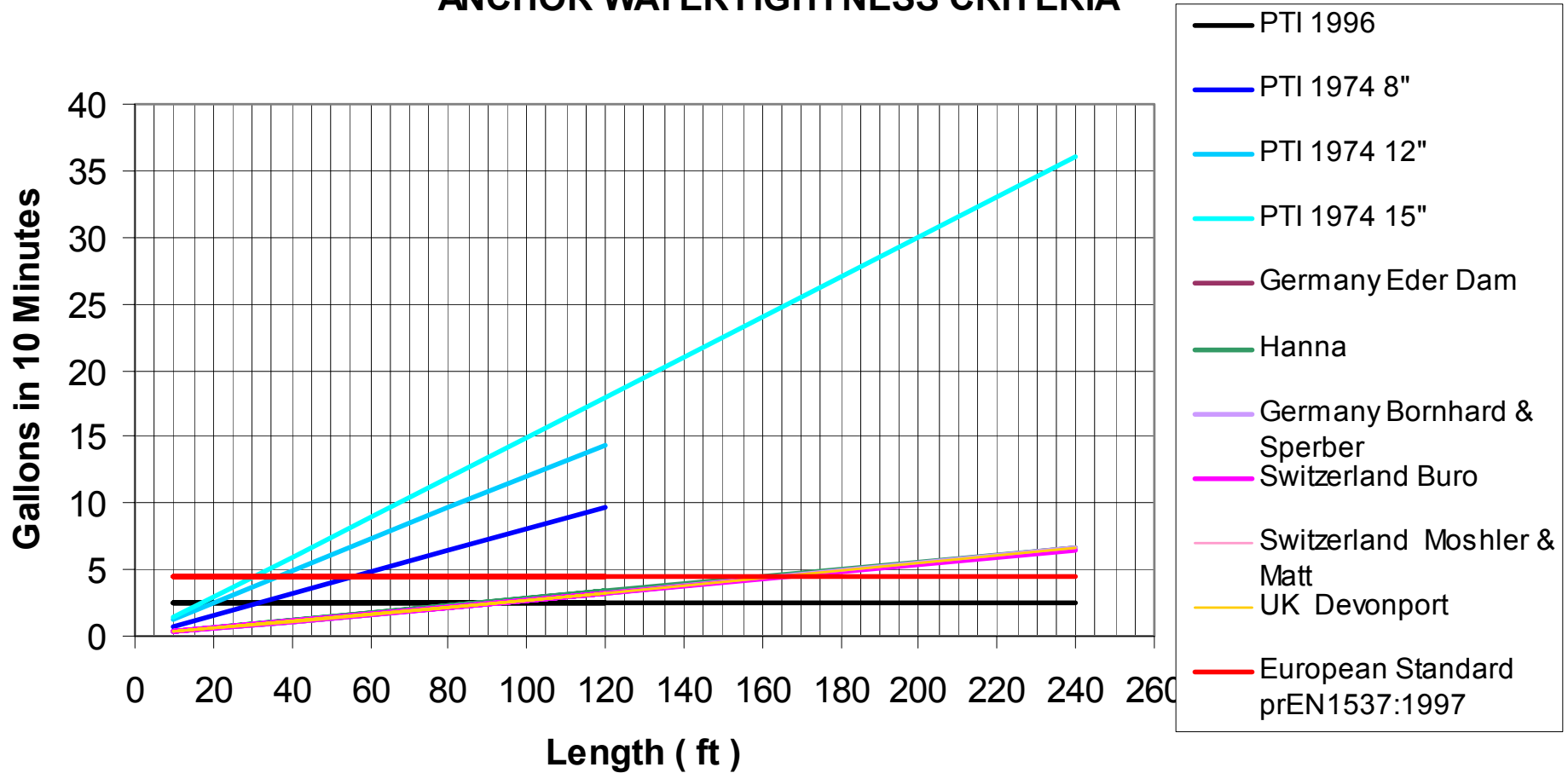




# *Watertightness Testing*

- Projects follow guidelines established by the Post-Tensioning Institute.
- 1996 revised leakage rate criteria is 2 gallons over 10 minutes. Often old criteria (1986) is still being specified.
- Old criteria was 0.001 gpm per inch diameter per foot of depth.
- Hole is filled with water and subjected to 5-psi in excess of hydrostatic head, usually through a packer.
- Sometimes a “falling head” test is adequate to determine if hole is failing. Water level 5-psi minimum above reservoir elevation.
- Some specifications call for isolating hole in zones with packer to determine where leakage is occurring.

## ANCHOR WATERTIGHTNESS CRITERIA





# *Watertightness Testing*

- Intent of watertightness testing criteria should be revisited.
  - Original intent of PTI was to make sure you would not lose grout in the bond zone.
  - Concrete could fail because of cracks, while bond zone is in good shape.
  - Often the hydrostatic pressure of the grout column during single stage grouting is adequate to seal off any leaks.
  - However, when pregrouting corrugated in place or two-stage grouting, you don't have the excess hydrostatic grout pressure.
  - Grout w:c ratios may not be thin enough to seal off leaks that cause hole to fail multiple times.

# *Consolidation Grouting & Redrilling*

- Holes are typically tremie grouted with 0.45 to 0.66 water/cement ratios and redrilled between 12 and 24 hours.
- Important not to let grout get stronger than surrounding area that you are drilling so bit doesn't drift off of original hole.
- Grout must be hard enough that it doesn't plug up the hammer bit.
- Mostly redrilling is done with same down-hole-hammer drill tooling.
- Sometimes redrilling is done with roller bit and water.



# *Setting Bearing Plate/Trumpet* *Assembly*

- Detail at upper anchorage is governed by tendon diameter vs bearing plate hole diameter.
  - If corrugated corrosion protection is not used, plate can be set in advance of tendon.
  - If corrugated is used, a sub plate/trumpet assembly is set prior to corrugated being installed then bearing plate is set on sub plate.
- Bearing plates/trumpets are set on non-shrink grout mixed to a mortar consistency.
- Sub bearing plate/trumpets can be set in place and a fluid non-shrink grout poured around the outside of the trumpet.
- Air in void around trumpet must be vented if trumpet is not pregouted in place.



# *Installation & Grouting*

- Equipment - mixing of cement grout is done with high shear colloidal mixers. Grout is pumped through a Moyno type progressive screw cavity pumps.
- Single-stage vs two-stage grouting
  - Single-stage grouting is done with greased and sheathed strands. The grout is tremie grouted in one lift to within 5 to 10-ft from top.
  - Two-stage grouting is when bond zone is grouted first followed by the free length after stressing and acceptance of the anchor.
  - Two-stage grouting is required for a fully bonded tendon (not permanently unbonded in the free length).
  - For various technical reasons, two-stage grouting may also be chosen for unbonded tendons.



# *Installation & Grouting -* *Corrugated*

- Corrugated sheathing is usually only shop installed up to 4” diameter.
- Can only use shop installed corrugated for crane installations, not good on uncoiler.
- Typically corrugated is installed in hole then tendon set into the corrugated prior to grouting.
- Tendon is then grouted on inside and outside of corrugated simultaneously.
- For long or angled tendons of large corrugated, must grout corrugated in place prior to installing tendon.

# *Installation & Grouting -* *Corrugated*

- It is important to have a high quality seal on end cap prior to placing corrugated.
- When stage grouting corrugated a plug is usually grouted at bottom to prevent floating.
- Stage grouting corrugated is a difficult process of balancing hydrostatic pressure of grout column on outside of corrugated to water on inside of corrugated.
- Multiple grout tubes are required to stage grout. Stages usually do not exceed 30-ft lifts.

# *Installation & Grouting - Tendons*

- Tendons are set with crane or uncoiled with hydraulic uncoiler into the corrugated.
- Most high capacity tendons come to the field with anchor heads (wedge plate) and wedges already installed.
- Steel bands in free length are cut during installation.
- Hang tendon under its own weight on frames.
- After first stage or primary grouting, set head and wedges into place for stressing.



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Taped. Fasten  
Tried Side

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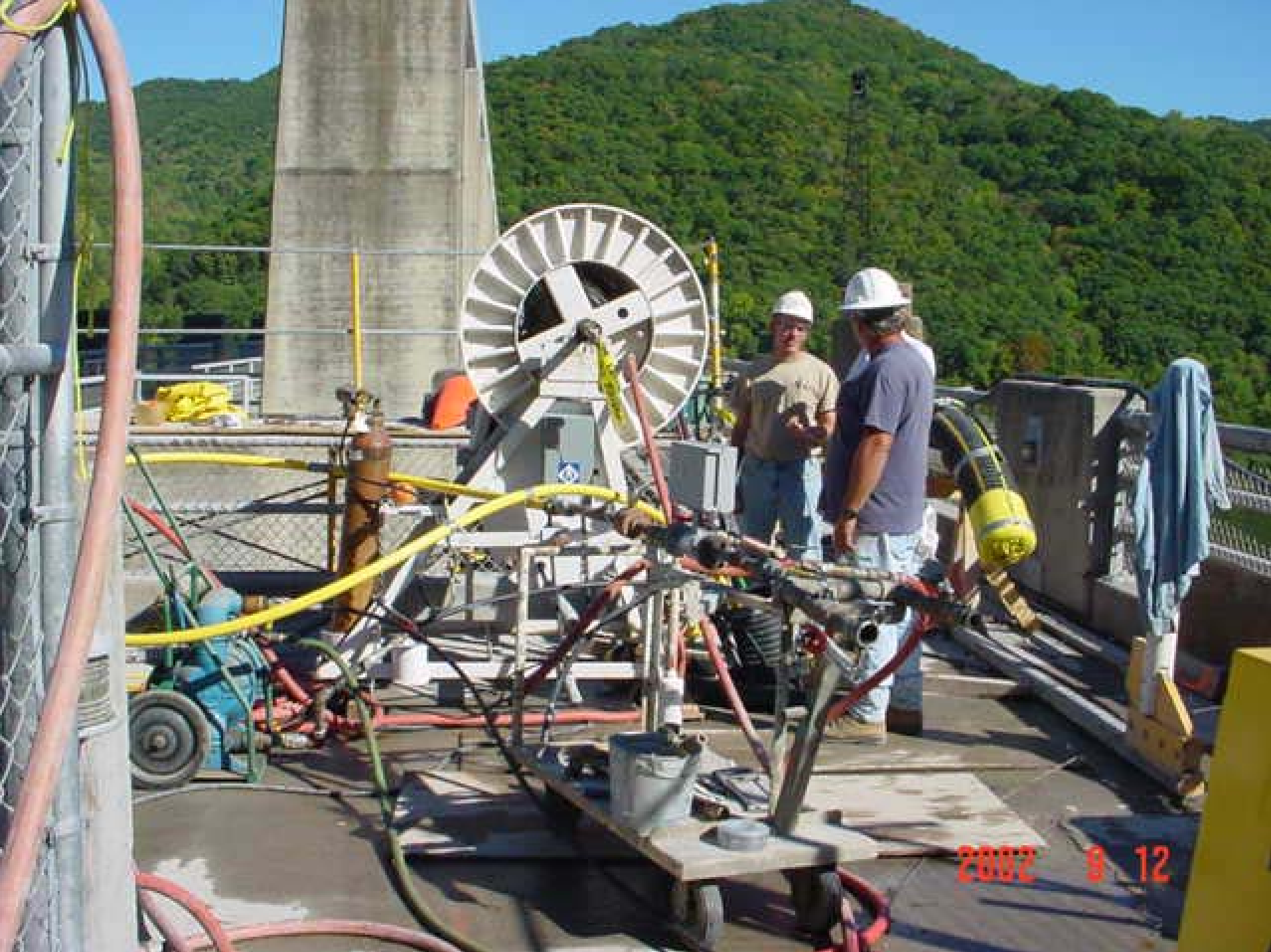




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